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Year: 2015

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## **Hilarcotherium castanedaii, gen. et sp. nov., a new Miocene astrapothere (Mammalia, Astrapotheriidae) from the Upper Magdalena Valley, Colombia**

Vallejo-Pareja, M C ; Carrillo, J D ; Moreno-Bernal, J W ; Pardo-Jaramillo, M ; Rodriguez-Gonzalez, D F ; Muñoz-Duran, J

**Abstract:** Astrapotheria is an order of extinct South American herbivores recorded throughout the continent, from the late Paleocene to middle Miocene. Here we describe *Hilarcotherium castanedaii*, gen. et sp. nov., an Uruguaytheriinae astrapothere from sediments of La Victoria Formation (middle Miocene) in the Tolima Department, Upper Magdalena Valley, Colombia. *H. castanedaii*, represented by a partial skull, mandible, and some postcranial remains, is characterized by (1) unique dental formula, with 0/3i, 1/1c, 1/1p, and 3/3 m; and (2) lower canines with subtriangular transverse section at the base. *Hilarcotherium* differs from the equatorial Uruguaytheriinae genera *Xenastrapotherium* and *Granastrapotherium* in (1) having three lower incisors; (2) the diagonal implantation of the lower canines; (3) lower molars with lingual cingulid; (4) the presence of the hypocone in the third upper molar; and (5) the presence of an anterolingual pocket in the fourth upper premolar. Our phylogenetic analysis supports the monophyly of the subfamilies Astrapotheriinae and Uruguaytheriinae. Within the latter, we confirm the monophyly of the neotropical clade (*Hilarcotherium*, *Xenastrapotherium*, and *Granastrapotherium*). *H. castanedaii* shows some plesiomorphic features such as the aforementioned presence of the i3 and the developed hypocone in the last upper molar. Its estimated body mass (1303 kg) is intermediate among Astrapotheriidae. <http://zoobank.org/urn:lsid:zoobank.org:pub:82377B38-8B39-4D71-9117-FD17CB329238> SUPPLEMENTAL DATA—Supplemental materials are available for this article for free at [www.tandfonline.com/UJVP](http://www.tandfonline.com/UJVP)

DOI: <https://doi.org/10.1080/02724634.2014.903960>

Posted at the Zurich Open Repository and Archive, University of Zurich

ZORA URL: <https://doi.org/10.5167/uzh-109178>

Journal Article

Accepted Version

Originally published at:

Vallejo-Pareja, M C; Carrillo, J D; Moreno-Bernal, J W; Pardo-Jaramillo, M; Rodriguez-Gonzalez, D F; Muñoz-Duran, J (2015). *Hilarcotherium castanedaii*, gen. et sp. nov., a new Miocene astrapothere (Mammalia, Astrapotheriidae) from the Upper Magdalena Valley, Colombia. *Journal of Vertebrate Paleontology*:e903960.

DOI: <https://doi.org/10.1080/02724634.2014.903960>

*Hilarcotherium castanedaii* gen. et sp. nov., a new Miocene astrapothere (Mammalia,  
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RH: VALLEJO-PAREJA ETAL.—NEW ASTRAPOTHERE FROM COLOMBIA

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SUPPLEMENTARY DATA 1. List and definition of characters for the phylogenetic analysis.

1. i1. 0 = present; 1 = absent (Kramarz and Bond 2011)
2. i2. 0 = present; 1 = absent (Kramarz and Bond 2011)
3. i3. 0 = present; 1 = absent (Kramarz and Bond 2011)
4. Lower incisors, crown shape: 0 = simple (incisiform); 1 = bilobed (Cifelli 1993; Kramarz and Bond 2009, 2011)
5. Upper incisors: 0 = present; 1 = absent (Cifelli 1993)
6. Lower canines, implantation: 0 = Horizontal; 1 = Diagonal; 2 = Vertical (modified from Kramarz and Bond 2009, 2011)
7. Upper canines, anterior groove: 0 = absent; 1 = present. (Kramarz and Bond 2011)
8. Upper canines: 0 = rooted; 1 = rootless (Kramarz and Bond 2011)
9. Upper canines: 0 = strongly curved; 1 = nearly straight. (Kramarz and Bond 2011)
10. p2: 0 = present; 1 = absent (Kramarz and Bond 2009, 2011).
11. p3: 0 = present; 1 = absent (Kramarz and Bond 2009, 2011).
12. p3, paralophid: 0 = reduced or absent; 1 = well developed. (Kramarz and Bond 2011)
13. p4, paralophid: 0 = reduced; 1 = well developed (Kramarz and Bond 2011).
14. p4, hypoflexid: 0 = present; 1 = absent (Kramarz and Bond 2009, 2011)

### APPENDIX 3. (Continued)

15. P1: 0 = present; 1 = absent (Simpson 1957, Soria and Powell 1981, Soria and Bond 1984, Johnson and Madden 1997, Kramarz and Bond 2011).
16. P2: 0 = present; 1 = absent. (Simpson 1957, Soria and Powell 1981, Soria and Bond 1984, Johnson and Madden 1997, Kramarz and Bond 2011).
17. P2, central valley: 0 = absent; 1 = present. (Kramarz and Bond 2011).
18. P3: 0 = present; 1 = absent. (Simpson 1957, Simpson 1967 Soria and Powell 1981, Soria and Bond 1984, Johnson and Madden 1997, Kramarz and Bond 2011).
19. P3 hypocone: 0 = absent; 1 = present. (Kramarz and Bond 2011)
20. P4, parastilar fold: 0 = absent; 1 = present.
21. P3 and P4 size compared to molars: 0 = no reduced; 1 = reduced. (Kramarz and Bond 2009).
22. P4, labial fold of the metacone: 0 = absent; 1 = present (Kramarz and Bond 2009, 2011).
23. P4, anterolingual pocket: 0 = absent; 1 = present (Kramarz and Bond 2009, 2011).
24. P4, posterolingual cingulum: 0 = low posterolingual cingulum; 1 = broaden, elevated posterolingual cingulum; 2 = inflated posterolingual cingulum forming a well define hypocone. . (Kramarz and Bond 2011)
25. P4, lingual valley: 0 = absent; 1 = present. (Kramarz and Bond 2011)

### APPENDIX 3. (Continued)

26. m1 – m3, hypoflexid: 0 = deep; 1 = superficial; 2 = absent. (Kramarz and Bond 2009, 2011)
27. Molars labial cingulum: 0 = absent; 1 = present (Kramarz and Bond 2011)
28. m1 – m3, paraflexid: 0 = transverse, very penetrating; 1 = oblique, superficial. (Kramarz and Bond 2011)
29. Lower molar paralophid: 0 = reduced; 1 = well developed. (Kramarz and Bond 2009, 2011)
30. Lower molars, lingual cingulid: 0 = absent; 1 = present (Johnson and Madden 1997; Kramarz and Bond 2009, 2011).
31. Lower molars, entoconid: 0 = included into the posterolophid; 1 = bunoid, isolated; 2 = forming a distinct lophid (unordered) (Kramarz and Bond 2011).
32. m1- m3, pillar: 0 = absent; 1 = present, as a column; 2 = present, lophoid, enclosing with the metalophid a minute fossetid (unordered) (Kramarz and Bond 2011).
33. Length of m2: 0 = less than 20 mm; 1 = between 20 and 40 mm; 2 = more than 40 mm. (Kramarz and Bond 2011)
34. Upper molar parastyle: 0 = well develop; 1 = reduced. (Kramarz and Bond 2011)
35. M1, anterolingual pocket: 0 = absent; 1 = superficial; 2 = very penetrating, protocone anteriorly constricted. (Kramarz and Bond 2009, 2011)

### APPENDIX 3. (Continued)

36. M1 -M2, central valley: 0 =isolated; 1 = communicated with the hypoflexus.  
(Kramarz and Bond 2011)
37. M3, central valley: 0 = open lingually; 1 = enclosed by a posterolingual cingulum.  
(Kramarz and Bond 2011).
38. M3, hypocone: 0 = absent; 1 = present (Kramarz and Bond 2009, 2011).
39. M1- M2, hypocone: 0 = absent; 1 = present. (Kramarz and Bond 2009, 2011).
40. M1 – M3, hypocone; 0 = rounded; 1 = lophoid, lingually sharp. (Kramarz and Bond 2011)
41. M1 – M3, labial fold of the metacone: 0 = absent; 1 = present (Kramarz and Bond 2009, 2011).
42. M1-M2, metaloph: 0 = absent or incomplete (hypocone isolated); 1 = complete  
(Kramarz and Bond 2009, 2011).
43. Upper molars, lingual cingulum: 0 = absent; 1 = present (Kramarz and Bond 2011)
44. Upper molars, median fossette: 0 = present, even in worn stages; 1 = ephemeral.  
(Kramarz and Bond 2009, 2011)
45. Angular process extending posterior to the condyle: 0 = present; 1 = present  
(Kramarz and Bond 2009)
46. Ventral inflection of the mandible: 0 = absent; 1 = present. (Kramarz and Bond 2009)

### APPENDIX 3. (Continued)

47. Frontals: 0 = uninflated, narrow; 1 = broad, slightly domed; 2 = very broad, domed and inflated. (Johnson and Madden 1997; Kramarz and Bond 2009)
48. Bulla: 0 = attached; 1 = unattached. (Johnson and Madden 1997; Kramarz and Bond 2009)
49. Nasals: 0 = elongated; 1 = retracted. (Johnson and Madden 1997; Kramarz and Bond 2009)
50. Choanae: 0 = divided by a median septum of the palatine; 1 = undivided. (Johnson and Madden 1997; Kramarz and Bond 2009)
51. Pterygoid or palatine processes: 0 = anterior to choanae; 1 = slightly lateral to choanae; 2 = lateral to choanae, thickened ventrally. (Johnson and Madden 1997; Kramarz and Bond 2009)
52. Palatal portion of the palatines: 0 = broad, without lateral palatine notch; 1 = broad, with lateral palatine notch; 2 = narrow, elongate, broad, without lateral palatine notch. (Johnson and Madden 1997; Kramarz and Bond 2009)
53. Lacrimal and lacrimal foramen: 0 = on the orbital rim; 1 = within orbit, orbital rim projecting. (Johnson and Madden 1997; Kramarz and Bond 2009)
54. Zygomatic arches: 0 = not flaring, dorsoventrally shallow, maxillary root above M1-M2; 1 = not flaring, dorsally curved, dorsoventrally thick, maxillary root above M1-M2; 2 = flare widely, horizontal, dorsoventrally shallow, maxillary root above M2. (Johnson and Madden 1997; Kramarz and Bond 2009)

### APPENDIX 3. (Continued)

55. Sagittal and temporal crests: 0 = sagittal crest long, temporal crests weak; 1 = sagittal crest short, temporal crests strongly developed. (Johnson and Madden 1997; Kramarz and Bond 2009)
56. Infraorbital foramen: 0 = single foramen, positioned anterior to the orbit; 1 = multiple foramina, positioned anterior to orbit; 2 = single foramen, positioned near the orbit. (Kramarz and Bond 2009)
57. Supraoccipital: 0 = not constricted; 1 = constricted. (Johnson and Madden 1997; Kramarz and Bond 2009)
58. Occipital-squamosal contact: 0 = occipital exposure of mastoid; 1=extensive, no occipital exposure of mastoid. (Johnson and Madden 1997; Kramarz and Bond 2009)
59. Glenoid fossa: 0 = at the level of or anterior to the basioccipital–basisphenoid suture; 1 = posterior to the basioccipital–basisphenoid suture. (Johnson and Madden 1997; Kramarz and Bond 2009)
60. Post-tympanic process of the squamosal: 0 = very weak far removed from paraoccipital process, 1 = weak closely appressed to paraoccipital process, 2 = strong, closely appressed to paraoccipital process. (Johnson and Madden 1997; Kramarz and Bond 2009)
61. Cheek teeth, crown height: 0 = bunolophodont, very low crowned; 1 = lophodont, high crowned (crown height less than anteroposterior diameter); 2 = lophodont,



APPENDIX 3. (Continued)

slightly hypsodont (crown height greater than anteroposterior diameter). (Kramarz and Bond 2009)

62. M1-M2, *crista*. 0 = absent; 1 = present. (Kramarz and Bond 2011)

63. M1-M2, *crochet*. 0 = absent; 1 = present. (Kramarz and Bond 2011)

64. p4 entoconid. 0 = included into the posterolophid; 1 = bunoid, isolated; 2 = forming a distinct lophid (unordered) (Kramarz and Bond 2011)

SUPPLEMENTARY DATA 2. Character-taxon matrix used in the phylogenetic analysis of Astrapotheriidae. See Appendix 3 for character description. **A** = 0 or 1; **B** = 0 or 2; **C** = 1 or

2

Taxa	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
<i>Eoastrapostylops</i>	?	?	?	?	?	0	?	0	0	0	0	0	0	0	0
<i>Trigonostylops</i>	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
<i>Tetragonostylops</i>	0	0	0	?	0	0	0	0	0	0	0	0	0	0	0
<i>Albertogaudrya</i>	?	?	?	0	?	?	0	0	0	0	0	0	1	0	?
<i>Scaglia</i>	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
<i>Astraponotus</i>	0	0	0	1	?	2	0	0	0	0	0	1	1	0	1
<i>Maddenia</i>	?	?	?	?	?	1	0	1	0	1	0	0	0	1	1
<i>Parastrapotherium</i>	0	0	0	1	1	2	1	1	0	1	0	0	1	1	1
<i>Astrapotherium</i>	0	0	0	1	1	2	1	1	0	1	1	-	1	0	1
<i>Granastrapotherium</i>	1	1	1	-	1	0	0	1	1	1	1	-	1	1	1
<i>Astrapothericulus</i>	0	0	0	1	1	1	1	A	0	1	1	-	1	1	1
<i>Xenastrapotherium</i>	0	0	1	1	1	2	1	1	0	1	1	-	1	1	1
<i>Uruguaytherium</i>	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
<i>Comahuetherium</i>	?	?	?	?	?	?	1	1	1	?	?	?	?	?	1
<i>Hilarcotherium</i>	0	0	0	1	1	1	?	?	?	1	1	-	?	?	1

## APPENDIX 4. (Continued)

Taxa	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
<i>Eoastrapostylops</i>	0	0	0	0	1	0	0	0	0	0	0	0	-	0	0
<i>Trigonostylops</i>	0	0	0	0	1	0	1	0	0	0	0	A	-	0	0
<i>Tetragonostylops</i>	0	0	0	0	1	0	1	0	0	0	0	A	0	1	0
<i>Albertogaudrya</i>	0	?	0	1	?	0	1	0	1	0	0	1	0	1	0
<i>Scaglia</i>	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
<i>Astraponotus</i>	0	1	0	?	?	0	1	1	1	0	A	1	0	1	A
<i>Maddenia</i>	0	1	0	1	1	0	0	1	2	1	1	1	0	0	0
<i>Parastrapotherium</i>	1	-	0	0	1	1	0	1	0	1	1	1	0	1	0
<i>Astrapotherium</i>	1	-	0	0	1	1	0	1	0	1	0	1	0	1	1
<i>Granastrapotherium</i>	1	-	1	-	0	1	0	0	0	1	2	0	1	1	0
<i>Astrapothericulus</i>	1	-	0	0	0	1	0	1	0	1	0	1	0	1	1
<i>Xenastrapotherium</i>	1	-	0	0	1	1	0	0	0	1	2	0	1	1	0
<i>Uruguaytherium</i>	?	?	?	?	?	?	?	?	?	?	2	0	0	1	0
<i>Comahuetherium</i>	1	-	1	-	1	1	0	1	0	0	?	1	?	?	?
<i>Hilarcotherium</i>	1	-	1	-	?	1	0	1	0	1	2	0	1	1	1

## APPENDIX 4. (Continued)

Taxa	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
<i>Eoastrapostylops</i>	0	0	0	0	0	0	-	0	0	-	0	0	0	-	0
<i>Trigonostylops</i>	1	0	0	0	0	0	-	0	0	-	1	0	A	-	0
<i>Tetragonostylops</i>	0	0	0	0	0	0	-	1	1	0	1	A	1	-	0
<i>Albertogaudrya</i>	1	0	1	0	0	0	-	1	1	0	0	0	1	-	?
<i>Scaglia</i>	?	0	0	0	0	1	?	?	1	1	0	1	1	-	?
<i>Astraponotus</i>	C	0	1	0	0	1	-	1	1	1	0	1	1	-	0
<i>Maddenia</i>	1	0	0	0	1	1	-	1	1	1	0	1	1	0	A
<i>Parastrapotherium</i>	0	1	2	0	1	1	0	0	1	1	0	1	1	0	1
<i>Astrapotherium</i>	0	2	2	0	1	1	0	0	1	0	0	1	1	1	1
<i>Granastrapotherium</i>	0	0	2	1	1	1	0	0	1	0	0	1	0	1	1
<i>Astrapothericulus</i>	0	1	1	0	1	1	0	0	1	0	0	1	1	1	1
<i>Xenastrapotherium</i>	0	0	2	1	2	1	1	0	1	1	0	1	1	1	1
<i>Uruguaytherium</i>	?	0	2	?	?	?	?	?	?	?	?	?	?	?	?
<i>Comahuetherium</i>	?	?	1	0	1	1	1	0	1	1	0	1	1	0	?
<i>Hilarcotherium</i>	0	0	2	1	2	1	1	1	1	1	0	1	1	1	1

## APPENDIX 4. (Continued)

Taxa	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
<i>Eoastrapostylops</i>	0	0	?	0	?	?	?	?	?	0	0	?	?	?	?
<i>Trigonostylops</i>	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0
<i>Tetragonostylops</i>	1	?	1	0	?	?	?	?	?	?	?	?	?	?	?
<i>Albertogaudrya</i>	1	?	?	?	?	?	?	?	?	?	?	?	?	?	?
<i>Scaglia</i>	?	1	?	0	1	1	?	?	?	?	0	?	?	?	?
<i>Astraponotus</i>	1	?	?	?	?	?	?	?	?	?	?	?	?	?	?
<i>Maddenia</i>	1	?	?	?	?	?	?	?	?	?	?	?	?	?	?
<i>Parastrapotherium</i>	0	?	1	1	1	2	?	?	?	1	?	1	1	0	1
<i>Astrapotherium</i>	0	2	1	1	1	2	1	1	1	1	2	1	1	0	1
<i>Granastrapotherium</i>	0	?	1	?	1	?	2	?	2	1	2	?	?	1	2
<i>Astrapothericulus</i>	0	1	?	1	?	?	?	?	?	?	?	?	?	?	?
<i>Xenastrapotherium</i>	0	?	?	?	?	?	?	?	?	?	?	?	?	?	?
<i>Uruguaytherium</i>	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
<i>Comahuetherium</i>	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
<i>Hilarcotherium</i>	0	?	?	?	?	?	2	?	2	?	?	?	?	?	?

# APPENDIX 4. (Continued)

Taxa	61	62	63	64
<i>Eoastrapostylops</i>	0	0	0	0
<i>Trigonostylops</i>	0	0	0	1
<i>Tetragonostylops</i>	0	0	0	0
<i>Albertogaudrya</i>	1	0	0	0
<i>Scaglia</i>	1	0	0	?
<i>Astraponotus</i>	1	1	0	B
<i>Maddenia</i>	1	1	1	0
<i>Parastrapotherium</i>	2	1	1	0
<i>Astrapotherium</i>	2	1	1	0
<i>Granastrapotherium</i>	2	1	1	0
<i>Astrapothericulus</i>	2	1	1	0
<i>Xenastrapotherium</i>	2	1	1	0
<i>Uruguaytherium</i>	2	?	?	?
<i>Comahuetherium</i>	2	1	?	?
<i>Hilarcotherium</i>	1	1	1	?